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ABSTRACT

This third unit in chemistry is considered for any chemistry student and particularly the college-bound student. An understanding of the material included should enable the student to understand better the concepts in the Dynamic Nature of Atoms and Molecules which are essential for Organic Chemistry, the Chemistry of Carbon and Its Compounds and Qualitative Analysis. The student explores energy changes, solubility of chemicals, and chemical reactions by use of laboratory investigations and problem solving situations. The purpose of doing calculations is to apply the concepts and, therefore, the arithmetic is made as simple as the type of problem will allow. Eleven performance objectives are presented in detail. The course outline includes four major topics: (1) Phases of Matter; (2) Solutions; (3) Determination of [Change in Heat] for Chemical Reaction; and (4) Rates of Reaction. The entire curriculum is presented, including experiments, demonstrations, projects and reports presented by students. Audio-visual aids, including films, film loops, and film strips are suggested. A master sheet coordinating the curriculum is presented. (Author/EB)

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AUTHORIZED COURSE OF INSTRUCTION FOR THE QUINMESTER PROGRAM

ENERGY OF ATOMS AND MOLECULES

5316.05

SCIENCE
(Experimental)

SE 017 121

DADE COUNTY PUBLIC SCHOOLS

DIVISION OF INSTRUCTION • 1971

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SCIENCE

(Experimental)

Written by Jacquelin Buffaloe
for the
DIVISION OF INSTRUCTION
Dade County Public Schools
Miami, Florida
1972

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ENERGY OF ATOMS AND MOLECULES

COURSE DESCRIPTION

Energy of Atoms and Molecules is an ideal third quin in chemistry for any chemistry student and particularly the college bound student. An understanding of the material included should enable the student to better understand the concepts in Dynamic Nature of Atoms and Molecules which is essential for Organic Chemistry, Chemistry of Carbon and Its Compounds and Qualitative Analysis.

In Energy of Atoms and Molecules, the student will explore energy changes involving the changes of phase or state of matter, solubility of chemicals, and chemical reactions by the use of laboratory investigations and problem solving situations. Calculations of heats of reaction, energy needed for phase and temperature changes, amounts of chemicals needed to prepare solutions, and of gas volumes, experimentations and class discussions will explain the theory behind the calculations. The purpose of doing the calculations is to apply the concepts and therefore, the arithmetic will be made as simple as the type of problem will allow.

ENROLLMENT GUIDELINES

Students should have successfully completed Introduction to Chemistry, Reactions of Atoms and Molecules and Scientific Mathematics or show their readiness by passing a test.

STATE ADOPTED TEXTS

1. Choppin, Gregory R. and Jaffe, Bernard. Chemistry: Science of Matter, Energy, and Change. Morristown, New Jersey: Silver Burdett Company, 1966.

2. Greenstone, Arthur W., Sutman, Frank X., and Hollingworth, Leland G. Concepts in Chemistry. New York: Harcourt, Brace and World, Inc., 1966.

3. Metcalfe, Clark H., Williams, John E., and Castka, Joseph F. Modern Chemistry. New York: Holt, Rinehart and Winston, Inc., 1966.

4. O'Connor, Paul R., Davis, Joseph E., Jr., Haenisch, Edward L., MacNab, W. Keith, and McClellan, A.L. Chemistry: Experiments and Principles. Lexington, Mass: Raytheon Education Company, 1968.

PERFORMANCE OBJECTIVES

1. Using the structural differences in the three states or phases of matter as a basis for the answer, the student will explain in writing how it is possible for

   (1) bases and liquids to flow from one location to another while solids (a piece of iron) do not.

   (2) liquids and solids to have a definite volume at a given temperature while gases do not.

   (3) one mole of any gas to occupy 22.4 liters at STP while such a fact is not true for solids and liquids.

   (4) solids to have a definite shape and liquids and gases to take the shape of a container.

PERFORMANCE OBJECTIVES

2. Using the Kinetic Molecular Theory, the student will explain the relationship between

   (1) the pressure and volume of a gas when the number of particles and temperature are constant.

   (2) the volume and temperature of a gas when the number of particles and pressure are constant.

   (3) the pressure and temperature of a gas when the number of particles and volume are constant.

3. The student will solve problems involving changes in the pressure, volume, and temperature of a gas when the number of particles remains unchanged.

4. Given the formulas for five chemicals each containing no more than five atoms or ions (e.g. H_2), NH_3, NaCl, C as diamond or graphite, DH_4, Ne, Zn) and a periodic table, the student will state for each chemical the

   (1) type of solid based on bonding.

   (2) types of forces of attraction found between the particles in the chemical when the chemical is in the solid phase.

   (3) relative conductivity, hardness, boiling point, and solubility in water (as compared to the other four chemicals.)

   (4) reasons for the predictions made in (3) above.

5. The student will describe the conditions which exist on a molecular level in a sample of chemical at its boiling point.

6. The student will explain the energy changes needed to convert a chip of ice at a temperature below freezing to steam at a temperature above the boiling

point of water when the pressure is 1 atm. and the weight of the chip is known. (Assume five steps are necessary.)

7. The student will describe the procedure (including the calculations of amounts of solvent and solute needed) for the preparation of a given volume of a solution of a given molarity and a given percent by weight of solute.

8. FOR NURSING CHEMISTRY STUDENTS ONLY: The student will describe the procedure (including the necessary calculations) for the preparation of a given volume of a solution of a given normality.

9. The student will explain how and why the following factors vary with the concentration and type of solute in the solution.

   (1) vapor pressure
   (2) conductivity
   (3) boiling and melting points

10. Given an equation for a chemical reaction and a table of heats of formation, the student will use his knowledge of the Law of Additivity of Heat to determine the ΔH for the reaction.

11. Given an equation for a chemical reaction, the student will use his knowledge of the Collision Theory to explain how and why the rate of the reaction will or will not change when the following changes are made.

   (1) temperature is increased
   (2) concentration of one reactant is increased
   (3) pressure is increased
   (4) catalyst is added
   (5) volume of the reaction vessel is increased

COURSE OUTLINE

I. Three Phases of Matter

A. Basic differences in gases, liquids and solids

1. Structure
2. Volume, definite and molar
3. Shape of volume
4. Type of motion of particles

B. Gases

1. Pressure, temperature, and volume relationships explained on the basis of the Kinetic Molecular Theory with problem solving
2. Forces of attraction between gaseous molecules or atoms

C. Liquids

1. Lack of geometric structure
2. Forces of attraction between particles (hydrogen bonds)
3. Density and specific gravity

D. Solids

1. Types of solids based on relative position of particles (amorphous and crystalline)
2. Types of solids based on bonding

a) Forces of attraction between particles in each type of solid
b) Physical properties of solids explained using bonding as a basis (boiling and melting points, conductivity, hardness, solubility in water,etc.)

E. Changes of State

1. Condensation - critical temperature
2. Evaporation - vapor pressure

COURSE OUTLINE (CONT.)

3. Determination of boiling and melting points recognizing conditions which exist at those temperatures
4. Boiling point and pressure
5. Molar and specific heats of vaporization, condensation, melting, and fusion
6. Factors which determine the energy needed to change state
7. Specific heat (ratio of thermal capacity of a substance to the thermal capacity of water)
8. Sublimation

II. Solutions

A. Factors determining solubility

B. Methods of expressing solubility and concentration

1. Percent by weight and volume (% by volume for Nursing Chemistry only)
2. Molarity
3. Normality (stress in Nursing Chemistry)
4. Molality (optional)

III. Determination of ΔH for a Chemical Reaction

A. Using a calorimeter

B. Using the Law of Additivity of Heat

IV. Rates of Reaction

A. Factors which affect the rate of a chemical reaction

B. Collision Theory

EXPERIMENTS

Barrett, Richard L. and Price, Jack. Chemistry: A Modern Course Laboratory Manual. Columbus, Ohio: Charles E. Merrill Books, Inc., 1965.

1. Graham's Law - Rate of Diffusion (exp. 15, p.29)
2. Boyle's Law (exp. 18, p. 35)
3. Properties of Bases: Oxygen and Ammonia (exp. 19 p. 37)
4. Molar Volume of a Gas (exp. 20, p. 39)
5. Factors Affecting Solution (exp. 25, p. 51)
6. Crystallization (exp. 26, p. 53)

Castka, Joseph F., Metcalfe, H. Clark, and Williams, John E. Exercises and Experiments in Chemistry New York: Holt, Rinehart and Winston, 1966.

7. Molar Volume of a Gas (exp. 15, p. 157)
8. The Solid State Crystals and Crystallization (Exp. 21, p. 171)
9. Solution and Molecular Polarity (exp. 20, p. 167)
10. Solubility, Rate of Solution, Heat of Solution (exp. 22, p. 175)
11. Chemical Properties of Water (exp. 17, p. 161)
12. Rate of a Chemical Reaction (exp. 38, p. 231)

Chemistry 2: Advanced Placement Course Outline and Manual of Laboratory Activities. Curriculum Bulletin 8-D. Dade County Public Schools, 1966.

13. Boyle's Law (exp. 18, p. 105)
14. Charles' Law (exp. 19, p. 107)
15. Solubility (exp. 21, p. 113)
16. Heat of Neutralization (exp. 26, p. 129)
17. Reaction Principles (exp. 27, p. 132)

Davis, Joseph E., MacNab, W. Keith, Haenisch, Edward L., McClellan, A.L. and O'Connor, Paul R. Laboratory Manual for Chemistry: Experiments and Principles. Lexington, Mass. Raytheon Education Company, 1968.

18. Masses of Equal Volumes of Gases (exp. 5, p. 8)
19. Temperature Volume Relations (exp. 10, p. 26)

EXPERIMENTS (CONT.)

20. Reaction of Magnesium and Hydrochloric Acid (exp. 11, p. 32)
21. Energy Needed to Melt Ice (exp. 13, p. 42)
22. Energy of Crystallization (exp. 14, p. 43)
23. Cooling Behavior of a Solution (exp. 15, p. 44)
24. Warming and Cooling Behavior of a Pure Substance (exp. 12, p. 38)
25. Types of Solutions (exp. 18, p. 52)
26. Energy of Combustion (exp. 25, p. 64)
27. Heat of Reaction (exp. 26, p. 66)
28. Heat of Reaction for Combustion of Magnesium (exp. 27, p. 68)
29. A Study of Reaction Rates (exp. 28, p. 69)
30. Heat of Acid-Base Reactions (exp. 31, p.78)

Ferguson, Harold, Schmuckler, Joseph, and Siegelman, Irwin. Investigating Matter, Energy and Change. Morristown, New Jersey: Silver Burdett Co., 1966.

31. The Physical Behavior of Air (exp. 6, p. 39)
32. The Density of a Gas (exp. 7, p. 49)
33. The Mole and the Molar Volume (exp. 8, p. 53)
34. Heat Absorption and Heat Capacity (exp. 12, p. 87)
35. Chemical Change and Chemical Energy (exp. 17, p. 129)
36. The Rate of a Chemical Reaction (exp. 18, p. 139)
37. Solutions and Solubility (exp. 20, p. 153)

Geffner, Saul and Lauren, Paul. Experimental Chemistry and Workbook. New York: Amsco Publications, 1968.

38. Changes in Matter (exp. 4, p. 17)
39. Temperature and Change of State (Phase Change) (exp. 5, p. 21)
40. Solutions (exp. 8, p. 33)
41. Making a Solubility Curve (exp. 9, p. 37)
42. Boyle's Law (exp. 12, p. 47)
43. Charles' Law (exp. 13, p. 51)
44. Relative Weights of Gases (exp. 14, p. 55)
45. Stoichiometry and Chemical Change (Mg and HCl) (exp. 15, P. 59)
46. Thermochemistry: Heat of Neutralization (exp. 15, p. 59)

47. Energy and Chemical Change (ΔH, ΔS, ΔG) (exp. 16, p. 65)

48. Thermochemistry: The Molar Heat of Reaction (exp. 19, p. 79)
49. The Rate of a Reaction (exp. 20, p. 81)
50. Crystal Models (exp. 35, p. 139)

Greenstone, Arthur W. Concepts in Chemistry Laboratory Manual. Atlanta: Harcourt, Brace and World, 1966.

51. Basic Crystal Structure (exp. 12, p. 50)
52. Ionic Crystals (exp. 13, p. 53)
53. Boyle's Law (exp. 14, p. 57)
54. Charles' Law (exp. 15, p. 60)
55. Solutions and Suspensions (exp. 16, p. 62)
56. Factors Affecting Solutions (exp. 17, p. 65)
57. Establishing the Solubility Curve of a Solid (exp.20,p.73)
58. Rates of Reactions (exp. 26, p. 86)
59. Molecular Polarity (exp. 29, p. 92)

Pimentel, George C., ed. Chemistry: An Experimental Science Laboratory Manual. San Francisco: W. H. Freeman and Co., 1963.

60. Melting Temperature of a Pure Substance (exp. 3, p.4)
61. Weight of Equal Volumes of Gases (exp. 6, p. 14)
62. A Quantitative Investigation of the Reaction of a Metal with Hydrochloric Acid (exp. 9, p. 26)
63. The Heat of Reaction (exp. 13, p. 39)
64. A Study of Reaction Rates (exp. 14, p. 41)
65. Heat of Some Acid-Base Reactions (exp. 17, p.48)
66. The Packing of Atoms or Ions in Crystals (exp. 27, p. 72)

Smith, William T., Jr., and Wood, Jesse H. Laboratory Manual for College Chemistry. New York: Harper and Row, Publishers, 1966.

67. Charles' Law (exp. 12, p. 51)
68. Molar Gas Volume (exp. 16, p. 69)
69. Solutions: Colligative Properties I and II (exps. 19 and 20, pp. 81 and 85)
70. Reaction Rates (exp. 23, p. 97)
71. Enthalpy Change of a Chemical Reaction (exp.27,p.115)

72. Special Projects: Crystal Growth (exp. 32 , p. 138)

Weaver, Albert C. Scientific Experiments in Chemistry. New York: Holt, Rinehart and Winston, Inc., 1966.

73. Effect of Ion Size on Mutual Solubility (exp. 7, p.14)
74. Diffusion (exp. 13, p. 24)
75. The Mole (exp. 14, p. 26)
76. Gay-Lussac's Law (exp. 15, p. 27)
77. Distillation of Liquids (exp. 18, p. 33)
78. Melting of Solids (exp. 19, p. 34)
79. Making a Solubility Curve (exp. 20, p. 36)
80. Finding Molecular Weights (exp. 22, p. 40)
81. Rates of Reaction as Determined by Strong and Weak Acids (exp. 28, p. 54)
82. Effect of Concentration on Rate of Reaction (exp. 41, p. 79)
83. Concentration of Hydrogen Peroxide and Its Decomposition Rate (exp. 42, p. 81)
84. Effect of Temperature on Rate of a Reaction (exp. 43, p. 82)
85. Effect of a Catalyst on Reaction Rates (exp. 44, p. 84)

DEMONSTRATIONS

Alyea, Hubert N. and Dutton, Frederic B. Tested Demonstrations in General Chemistry. Easton, Penn. Division of the American Chemical Society, 1966.

1. Models of Kinetic Motion (p. 63)
2. Motion in Gases, Liquids and Solids (pp. 63-64)
3. Boyle's Law (p. 64)
4. Charles' Law (p. 64)
5. Deviation from Ideal Gas Laws (p. 64)
6. Graham's Law of Effusion (p. 64)
7. Fluid Flow (p. 66)
8. The Liquid State (p. 66)
9. Solubility (pp. 66 and 67)
10. Rate of Solution (p. 67)
11. Solubility Curves (p. 67)
12. Specific Gravity (p. 67)
13. The Solid State - Growing Crystals (p. 69)
14. Sublimation (p. 71)

DEMONSTRATIONS (CONT.)

15. Conductivity Measurements (p. 75)
16. Conductivity Test Set (p. 148)
17. Heats of Transition (phase changes) (p. 79)
18. Heats of Reaction (p. 79)
19. Rate of Reaction and Effects on Rate of Reaction (pp. 84 and 85)
20. Hydrogen Bonding in Liquids (p. 143)
21. Dalton's Laws of Partial Pressure (p. 195)
22. Colored Clock Reactions (p. 147)
23. Old Nassau Reaction (p. 19)
24. Strength of Solutions (p. 14)

McClellan, A. L., ed. Teachers Guide for Chemistry an Experimental Science. San Francisco: W. H. Freeman and Company, 1963.

25. Electrical Conductivity (p. 157)
26. Phase Changes of Iron (p. 735)
27. Pressure in Tire (p. 58)
28. Pressure-Temperature Relation (p. 125)
29. Vapor Pressure of a Liquid at Two Temperatures (p. 155)

PROJECTS

1. Devise the apparatus and procedure for determining the approximate atomic weight using the Dulong and Petit method.

2. Devise apparatus and procedure to measure the
   (a) vapor pressure of a volatile chemical at various temperatures.
   (b) conductivity of chemicals and solutions.
   (c) Δ H of a simple reaction such as the burning of a peanut or a piece of candle wax.

3. Based on a knowledge of the properties of solutions and how they cause the vapor pressure to vary, perfect a method of separating a 2 or 3 component

PROJECTS (CONT.)

system of water and other volatile materials.

4. Measure and explain the variation of conductivity of an electrolyte in water as the concentration increases.

5. Prepare standard solutions and titrate to determine the percentage of acetic acid in various brands of vinegar.

6. Grow crystals - test various factors such as temperature, effect of foreign agents, etc., on the rate of growth or perfection of the crystals.

7. Based on structure and bond type, predict the solubility of several chemicals in water and alcohol. Then test to determine the accuracy of your prediction.

8. Determine the molecular weight using the Victor Meyer or Dumas Methods.

9. Analyze water for mineral content or possible pollutants.

10. Make bubble models of crystal structures. Make various tests such as foreign particles, etc.

REPORTS

1. Experimental methods for the determination of boiling and melting point.

2. Ways (mechanism) in which chemicals dissolve in water.

3. Explanation (based on structure) of the properties of the five types of solids.

4. Factors which determine the solubility of a chemical in water.

5. A survey of various crystalline structures (include what chemicals have what structures, and an explanation of factors which can be used to predict crystalline structures)

6. Ways in which solutions of specific concentrations can be used to experimentally determine important information.

7. State, explain, and write a lab procedure to illustrate each of the gas laws.

8. Explanation of the physical properties of water based on structure.

SPEAKERS AND FIELD TRIPS

1. American Society of Medical Technologists
   Mrs. Anna Rundell
   2213 Red Road, Coral Gables

2. Dade County Air and Water Pollution Control
   864 N. W. 23rd Street 377-5891

3. University of Miami School of Medicine
   Director of Public Relations
   Sewell Building 1477 NW 12th Avenue 350-6256

RELATED MATH PROBLEMS

1. Ten (10) liters of oxygen gas were measured over water at a temperature of 25°C and a pressure of 756 mm (Torr). What volume of dry gas would there be at STP?

2. A sample of gas occupies 5.2 liters at 26°C and 580 mm (Torr). What will the pressure be if the volume is increased to 7.8 liters and the temperature changes to 13°C?

3. Three (3) grams of a gas occupy 1.8 liters at STP. What is the mass of one mole of the gas?

4. Fourteen (14) grams of nitrogen gas and 8 grams of oxygen gas are enclosed in an airtight jug. (a) If the conditions are normal, what is the volume of the nitrogen and what is the volume of the oxygen? (b) What fraction of the pressure is produced by each gas?

5. How many calories will it take to change 4 grams of ice at -4°C to steam at 104°C with the pressure at 1 atm? (Specific heats of ice and steam are .5 calories per gram per degree.)

RELATED MATH PROBLEMS (CONT.)

6. What is the molarity of a solution composed of 8.96 grams of H_2SO_4 in 396 ml of solution?

7. What weight of solute is needed to prepare 1.5 liters of 0.025 M $KMnO_4$ solution?

8. What weight of NaCl and volume of water (assuming 1 g/ml) is needed to prepare a 12% salt solution?

9. NURSING CHEMISTRY ONLY

What weight of each solute listed below is needed to prepare 500 ml of a .01N solution

(a) HCl
(b) $Ca(OH)_2$
(c) H_3PO_4
(d) $Cu(NO_3)_2$
(e) $AlCl_3$
(f) NaOH

10. Given the equations below, calculate the heat of formation of one mole of $PbSO_4$ from the elements.

$$Pb(s) + S(s) \rightarrow PbS + 22.54 \text{ kcal}$$
$$PbS(s) + 2O_2(g) \rightarrow PbSO_4(s) + 196.96 \text{ kcal.}$$

11. Using a table of heats of formation, determine the ΔH for the combustion of C_3H_8. Show that you used Hess' Law or the Law of Additivity of Heat.

12. A leak proof balloon has a volume of one cubic foot at 25°C. (a) What will the volume be at 50°C (pressure constant)? (b) If the container was not a balloon but was more like an automobile tire, what would the pressure be at 50°C. (Assume no change in volume.)

FILMS

Available from Dade County Audio-Visual Center

1. Crystals and Their Structure
   1-10824 22 min. B/W
2. Crystals
   1-30342 25 min. B/W
3. Demonstrating the Gas Laws
   1-10740 21 min. C
4. Gas Pressure and Molecular Collision
   1-10849 21 min. B/W
5. Gases and How They Combine
   1-10844 22 min. C
6. Gas Laws and Their Application
   1-10720 16 min. B/W
7. Introduction to Reaction Kinetics
   1-10859 13 min. C
8. Laws of Gases
   1-01831 10 min. B/W
9. Molecular Motion
   1-10874 63 min. C
10. Properties of Solutions
    1-30345 28 min. B/W
11. Properties of Water
    1-01965 10 min. B/W
12. Solids, Liquids, and Gases
    1-01739 10 min. B/W
13. Solutions
    1-10928 16 min. C
14. Standard Solutions and Titration
    1-10926 21 min. B/W
15. Velocity of Chemical Reactions
    1-01960 11 min. B/W
16. Catalysis
    1-10809 16 min. C
17. Catalysis
    1-01959 11 min. B/W
18. Behavior of Gases (PSSC)
    1-10717 15 min. B/W
19. Crystals
    1-30342 25 min. B/W

FILMS (CONT.)

Yale Chemistry Films, Association Films, Inc., 347 Madison Avenue, N.Y., N. Y. 10017.

20. Bomb Calorimeter (YF-223)
    9 min. C
21. Triple Point Determination (YF233)
    15 min. C
22. Vapor Pressure (YF250)
    7 min. C

FILM STRIPS

McGraw Hill Book Co. Text Films Dept., 330 W 42nd St. N. Y., N.Y.

1. Kinetic Molecular Theory color

Jam Handy Organization, 2821 E. Grand Blvd., Detroit 11, Mich.

2. Gas Pressure 64 frames B/W

Film Strip of the Month Club, 355 Lexington Ave., N.Y. 17, N.Y.

3. Crystals and Their Properties

FILM LOOPS

Ealing Film-Loops, 2225 Massachusetts Avenue, Cambridge, Mass. 02140

1.	Handling Solids and Liquids	84-0017
2.	Reaction Rates	84-0231
3.	Critical Temperature	80-2058
4.	Diffusion	80-2959
5.	Gas Diffusion Rates	80-3379
6.	Heat of Fusion	80-3429
7.	The Melting Temperature of a Pure Substance	80-3411
8.	Properties of Gases	80-2967
9.	Thermal Expansion of Gases	80-3312
10.	Thermal Expansion of Solids	80-3296
11.	Thermal Expansion of Liquids	80-3304
12.	Identifying Solids by Density	80-3362
13.	Identifying Liquids by Density	80-3270
14.	Identifying Gases by Density	80-3288
15.	Boiling Point and Pressure	80-3403
16.	Boyles Law	80-3387
17.	Finding Absolute Zero	80-3395

Yale Chemistry Films, Association Films, Inc., 347 Madison Avenue, N.Y., N. Y. 10017

18. The Hydrogen Fountain
    YF-222 3 min. C
19. Solution, Evaporation and Crystallization
    YF-239 3 min. C

SUGGESTED DISCUSSION QUESTIONS

1. How could you make a candle burn faster?

2. In a factory where raw milk is converted into various dairy products, how would you express the rate of production?

3. What is the difference in temperature and heat?

4. Under what circumstances would the rate of a reaction not be affected by the increase in the amount of a reactant present?

5. Why does the temperature have a greater effect on the rate of a reaction than the concentration.

6. What factors determine the solubility of a chemical in water?

7. List the types of forces that exist between the molecules. What properties do they create?

8. Why do we need various methods of determining concentration of a solution? How are these solutions used?

9. What is the difference in the strength and concentration of a chemical?

10. Why must we talk about average kinetic energy when discussing the Kinetic Molecular Theory in relation to the behavior of matter?

11. How can you explain that water evaporates below $100^{o}C$ at 1 atm pressure?

12. Considering the properties of gases vs. liquids and solids, why is it reasonable that we should know more about the chemical and physical nature of gases?

13. Why should more energy be needed to boil a salt solution than pure water?

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4. Campbell, Arthur J. Why Do Chemical Reactions Occur? Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1965.

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Objectives	Texts	References	Experiments	Films	Problems	Questions	Reports	Projects	Demonstrations	Film loops	Film strips
1	#1 pp. 51,86, 143,144, 150 #2 pp. 129-141 #3 pp. 142-154, 159-162, 167 #4 pp. 55-67, 71-73	#1 pp. 34-36,26-29 #3 pp. 33,34,46-49 245-250 #5 pp. 12,13,24, 37,38 #7 pp. 436-443 #9 pp. 50,51,82, 95,116,121 #14 pp. 49-53, 117-119 #16 pp. 133,134, 167-170,177 #18 pp. 17,53,62, 446 #19 pp. 44-50 #21 pp. 421-426	3,4,7,8,18, 31,32,33, 43,61,68, 75	9,12, 21	3	7,10, 11,12			1,2,7-9, 12	1, 9-14	1
2	#1 pp. 50-63 #2 pp. 125-129 #3 pp. 125-138 #4 pp. 55-67	#1 pp. 4-10 #3 pp. 33-38,46-58 #5 pp. 13-28 #9 pp. 37-50 #14 pp. 53-60 #16 pp. 138-157 #18 pp. 18-39	1,2,3,13, 14,19,42, 43,53,54, 67,74,76	3,4, 5,6, 8,18		10	7	8	3-6,21, 27,28	3,4, 8,16, 17,18	2
3	#1 pp. 53-63 #2 pp. 146-152 #3 pp. 129-138 #4 pp. 55-67	#1 pp. 7-10 #3 pp. 49-54 #5 pp. 13-28 #6 pp. 229,330 #7 p. 438 #9 pp. 44-50 #14 pp. 53-60 #15 pp. 13-25 #16 pp. 138-157 #17 pp. 226-248 #18 pp. 19-38, 46-48, 61	1,2,13,14, 19,20,42, 43,45,53, 54,67,62, 76	3,4, 5,8, 18	1,2,4, 12	10	7	8	3-6,21, 27,28	4,5, 8,16, 17,18	
4	#1 pp. 153-163, 288-302 #2 pp. 138-142 #3 pp. 168-178 #4 pp. 329-352	#1 pp. 52-55,36-39 #3 pp. 49-54 #9 pp. 82-91, 100-109 #12 pp. 221-228, 203 #13 pp. 449-472, 393 #14 pp. 300-317 #16 pp. 158,178 #18 pp. 191-205, 259-261 #19 pp. 172-188, 196-199 #20 pp. 14-21	5,6,8,9,11, 15,24,25, 39,50,51, 59,60,66, 72,78,79	1,2, 11,19		6,7	2,4,5, 8	6,7, 10	13,20		3
5	#1 p. 150 #2 pp. 136-138 #3 pp. 164-165 #4 pp. 75-78	#3 p. 254 #5 pp. 38-44 #9 pp. 128,129 #14 p. 67 #16 pp. 170-174 #18 pp. 55-58 #19 pp. 44-50	24	22		13	1	2	29	7,15	

Objectives	Texts	References	Experiments	Films	Problems	Questions	Reports	Projects	Demonstrations	Film Loops	Filmstrips
6	#1 pp. 145-160 #2 pp. 156-159 #4 pp. 73-78	#1 pp. 156-171, 212-223 #3 pp. 49-51 #5 pp. 43-45,262 #9 p. 122 #14 pp. 66-69 #15 pp. 132-135 #16 pp. 191-198 #17 pp. 278-283 #18 pp. 58, 63	21,22,38		5				14,17,26	6,19	
7	#1 pp. 348-350 #2 pp. 180-190 #3 pp. 229,230 #4 pp. 86-88	#3 p. 256 #5 p. 68 #6 pp. 231,232 #9 pp. 133,134 #11 pp. 41-43 #14 p. 72 #15 pp. 78-83 #16 pp. 210,232-239 #17 pp. 319-322, 332,338 #18 pp. 333-338 #20 p. 32	37,55	10,13, 14	6,7,8	8,9	6,8	5,9	24		
8	#2 pp. 188,189 #3 pp. 231,232	#3 p. 257 #5 p. 68 #9 p. 134 #11 pp. 44-48 #15 pp. 83-87,93-99 #16 pp. 210,232-239 #17 pp. 323-328 #18 p. 339 #20 pp. 32,33		13,14	9	8,9	5,9	24			
				(Speakers and Field Trips 1,2,3,4 correlate with Objectives 7 and 8)							
9	#1 pp. 353-357, 360,361 #2 pp. 191-196, 201-214 #3 pp. 196-199, 202-213 #4 pp. 84-86, 88-97	#1 pp. 184-185 #2 pp. 101-150 #3 pp. 255-268, 277,280 #5 pp. 79-82,91-98 #9 pp. 132,136-143 #14 pp. 70,71,73 #16 pp. 210-221 #18 pp. 346-354	5,22,40, 41,56,57, 69,73,77,80	22		9,13		2,3,4	15,16, 25		
10	#1 pp. 304-316 #2 pp. 161-163 #3 pp. 322-346 #4 pp. 192-201	#1 pp. 112-119 #2 pp. 1-38 #3 pp. 213-220 #5 pp. 280-282 #9 pp. 275-279 #10 pp. 27-37 #12 pp. 61-67 #13 pp. 91-94 #14 pp. 108-117 #15 pp. 136-138 #16 pp. 123-126 #17 pp. 283-292 #18 pp. 217-223	10,12,16, 26,27,28, 30,34,35, 46,47,48, 63,65,71, 78	20	10,11	3		1,2	17,18	6	
11	#1 pp. 318-331 #2 pp. 163-167, 263-268 #3 pp. 346-351 #4 pp. 207-223	#1 pp. 346-366 #2 pp. 39-52 #4 pp. 1-63 #5 pp. 360-378 #8 pp. 1-90 #9 pp. 317-348 #14 pp. 124-139 #16 pp. 253-265 #18 pp. 281-300 #19 pp. 118-158 #20 pp. 42-44	10,17,29, 36,49,58, 64,70,81, 82,83,84, 85	7,15, 16,17		1,2,4, 5			10,19,22, 23	2	